

JUNE 2004

Ergonomics at Home

LAWRENCE LIVERMORE NATIONAL LABORATORY

Administrative Information Only

Introduction	1
Section 1. Computer Workstations	2
Ergonomic Tips and Solutions for Computer Workstations	2
Diagram for positioning Equipment at the Workstation	4
There's More Than One Correct Way to Sit	5
Step-by-Step Chair Adjustment Guide	8
Section 2. Laptops, Hand Tools, and Back Care	9
Use of Laptop Computers	9
Tips for Selecting and Using Hand Tools	11
Lifting and Back Safety Awareness	11
Section 3. Ergonomics for Children	13
Guidelines for Computer Work	13
Guidelines for Electronic Games	14
Backpack Safety	16
Section 4. Ergonomic Resources and Web Site	17

Introduction

This booklet is dedicated to your good health. Our goal is to provide you with information that will enable you and your family to apply the same ergonomic practices at home as you do at work to avoid repetitive strain or overexertion injuries. While the emphasis is on computer use, this booklet also provides guidelines on lifting, back care, and selecting and using hand tools. A section on ergonomics for children covers computer use, playing electronic games, and handling heavy backpacks.

An effort was made to keep all sections brief, so if you have further questions or want to discuss situations not covered in this document, feel free to contact the safety and health professionals at work or telephone 2-ERGO.

This document was prepared for the Laboratory Services Directorate by the Ergonomics Pilot Program team ergonomists, Melanie Alexandre, Cheryl Bennett, and Lois Halunen.

Section 1. Computer Workstations

ERGONOMIC TIPS AND SOLUTIONS FOR COMPUTER WORKSTATIONS

This section will provide you with ergonomic tips and solutions to help you optimize your home computer use. Also included are illustrations on correct postures and a resource list for ergonomic tools and equipment. If you use a laptop, read the section in this booklet that pertains specifically to laptop use.

Whenever you change one aspect of your computer workstation, another may be affected. For example, if

your chair must be raised, you may need a footrest. If you are considering spending some money on your home computer workstation, the purchase of an adjustable chair would probably provide the most ergonomic help. This is especially helpful if more than one person uses the computer. Good chairs are available for approximately one hundred dollars. Sit in any chair you are considering purchasing to make sure it is comfortable for you. Information on

chair selection and chair adjusting is included later in this booklet.

To adjust your home computer workstation, begin by asking a friend or family member to observe you as you sit at your workstation. Use the diagram at the end of this section as a guide. A photo of you at your workstation can also help you to see what changes need to be made. Below are some suggestions to help you adjust your workstation.

Problem: Monitor is too low

- Raise the monitor by placing old telephone books or several reams of paper beneath it.

Problem: Monitor is too high

- Make sure there is nothing under the monitor.
- Raise your chair.
- Add cushions to the seat of your chair. (You may need to add a footrest when you raise your chair or add cushions.)
- Lower the surface on which the monitor is placed.

Problem: There is glare on the monitor screen

- Lower the light level in the room.
- Close the blinds or curtains.
- Reposition the computer workstation away from window(s) or other source(s) of glare.

Problem: Keyboard/pointing device is too high

- Place keyboard or pointing device on your lap, supported by either: a book, a piece of wood, a firm pillow, or a three-ring binder (with rings/binding closest to body to create a negative tilt).

Low-cost option: Purchase a keyboard tray (available for under \$75).

Problem: Keyboard/pointing device is too low

- Lower the chair.
- Raise the keyboard height on desk by placing it on several magazines, a piece of plywood, firm card board, an old phone book, or a three-ring binder.

Problem: Mouse/trackball is not at same level as the keyboard

- Rearrange the items near the computer to provide enough space for the mouse/trackball to be placed next to keyboard.

Low-cost options: Purchase a “mouse bridge” that fits over the number pad on the right side of the keyboard and provides a platform for a mouse/trackball.

Purchase a keyboard tray that is wide enough for the keyboard and mouse.

Problem: Chair is uncomfortable or doesn't provide enough support

- Use cushions to pad or provide support for back or hips.
- Adjust the chair, if possible. (See section on chair adjustment on page 8.)

Problem: Chair must be raised too high for feet to touch the floor

- Create a footrest from a small box, old telephone books, or three ring binders.

Low-cost option: Purchase a footrest (available for less than \$20).

Problem: Incorrect posture habits, such as slumping, twisting or sitting with one leg tucked under the other

- Adjust the chair for better fit.
- Place a rolled-up towel or pillow under the upper thigh, at low-back area, or along spine.
- Use a footrest.
- Rearrange your entire computer setup using ergonomic considerations.
- Be more aware of incorrect postures and make an effort to change.
- Take rest breaks often. Use a kitchen timer, or see Web site listed in the Resource section of this booklet for free software that will remind you to take breaks. (See page 17.)

Low-cost option: Purchase an adjustable chair (available starting at \$100).

Problem: Sore Neck

- Lower your monitor to prevent your chin from tilting upward.
- Adjust your chair backrest forward for better support.
- Adjust the arms of your chair so they are below the natural bend of your elbow. You should not have to “shrug” your shoulders to rest your arms on the chair.
- Avoid holding the telephone receiver between you head and shoulder. Use the telephone’s “speaker” option if it is necessary to type while you are on the phone.
- Do not attach a shoulder rest to the telephone receiver as this encourages incorrect neck posture.
- Review the following section on vision as viewing habits often affect neck position.
- See your doctor if pain persists after making adjustments to your workstation as pain may indicate a serious problem.

Low cost option: Purchase a headset if you use the telephone often (available for less than \$100).

Problem: Sore Eyes or Vision Problems:

- Have your vision checked, and be sure to tell your optometrist that you use a computer.
- If you wear bifocal glasses, you may need single-vision computer glasses. This will prevent you from tilting your head upward when viewing the screen. Many vision benefit programs cover this cost.
- Move your chair closer to the monitor screen or pull the monitor closer.

- Increase the font size in your document or boost magnification to 125 or 150 percent.
- Review the section that discusses glare on the monitor screen.

Problem: Sore Wrists or Hands:

- Avoid trackball input devices that use thumb-operated rollers, as they can strain the thumb area if overused.
- Take rest breaks often. See the Resource section of this booklet for a Web site address for free software designed to remind you to take breaks.
- Try using your mouse/trackball on the other side of the keyboard. It takes about a week to get accustomed to pointing with your other hand and it is not a difficult transfer. Once you are used to it, you can alternate and divide the workload between your hands.
- Make all the adjustments recommended in this booklet to correct your keyboard height and chair arm height.

Problem: No Wrist-Rest Support

- Form a wrist rest by rolling up a small hand towel or using a strip of foam rubber taped to the desk edge with duct tape. You can also try using a gel pack from a camping supplies store.
- A wrist rest should only be used when the hands are not keyboarding or using pointing device. Pressure should never be applied directly on the wrist area, but rather, on the heels of the palm. Using the keyboard without a wrist rest is fine as long as your palm, wrists or forearms are not resting on something hard or with sharp edges.

Low-cost option: Purchase a wrist rest (available for under \$20).

Problem: No Document Holder

- If you like to have your documents directly in front of you, brace documents that you are using between the keyboard and monitor, supported by a piece of cardboard or a stiff file folder.
- Create a document holder by using adhesive Velcro strips attached to a plastic clip or clothespin. Place the clip holder to the outer edge of the monitor to hold papers closer and to elevate to eye level.

Low Cost option: Purchase a copyholder (available for less than \$10).

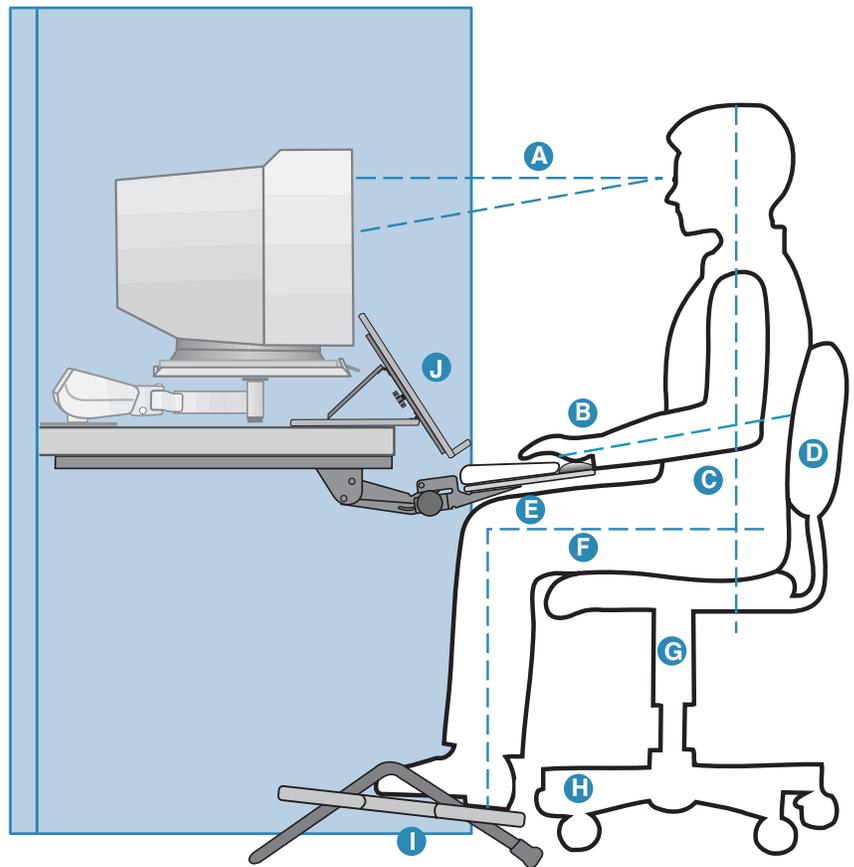
Important: See your doctor if pain persists after you have made adjustments to your workstation as that may indicate a serious problem.

Special note: If you have children or grandchildren who are using your computer or playing video or hand held games, read the Ergonomics for Children section in this booklet. (See page 13.)

The Ergonomically Positioned Workstation

Slouching, slumping or bending forward at the waist in a chair can lead to discomfort, fatigue and backache. Follow these guidelines to help prevent problems from occurring when sitting at your workstation.

- A. Top one-third of the screen at or below eye level; distance from operator a minimum of 18", typically at arm's length.
- B. Wrists should be a natural extension of the forearm, not angled up or down.
- C. Elbow relaxed. Lower arm open at least 100° to upper arm.
- D. Adjustable back rest to accommodate the normal curve of the lower spine.
- E. Keyboard flat at elbow level with palm rest to support hands during rest.
- F. Thighs approximately parallel to the floor.
- G. Easily adjustable seat height. Seat pan short enough (front to back) for knee clearance and with a waterfall front edge.
- H. Swivel chair with 5-point base and casters.
- I. Feet resting firmly on the floor; footrest needed if feet are not supported by the floor.
- J. Document holder in line with front of monitor. Height and angle adjusted for the comfort of the user.



THERE'S MORE THAN ONE WAY TO SIT RIGHT.

The right sitting support for one activity or person may be wrong for another. The same “ergonomic” chair or “orthopedic” back support cannot provide proper support for every person and every activity. Follow these steps to find your best seating product.

1. Fit your activity

You need different support for forward, upright, and reclined sitting. If you use one chair for a combination of tasks, such as writing (forward sitting), typing (upright sitting), and participating in meetings (reclined sitting), select a chair that will help where you spend most of your time.

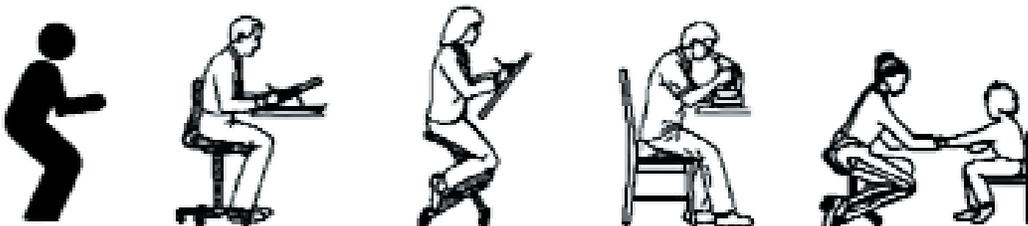
RECLINED SITTING POSTURES are used for resting, conversation, and other activities with the eyes focused forward or upward. Most people recline to watch TV, and some recline to drive or use a computer.



UPRIGHT SITTING POSTURES are used for working with the hands close to the body and the eyes focused straight ahead. Most people sit upright to type and eat, and some sit upright to drive or use a computer.



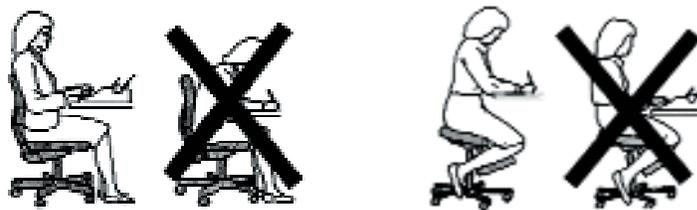
FORWARD SITTING POSTURES are used for reaching tasks and tasks with the eyes focused downward. Writing, drafting, dentistry, and using a microscope usually require forward postures.



You need different support for reclined, upright, and forward sitting.



A good support for an upright or reclined task may be ineffective or harmful if used for a forward task and vice versa.



Recommended use symbols

RECOMMENDED USE			
	Reclining	Upright	Forward
Excellent			
Good			
Fair			

We use these symbols to indicate the activities for which a chair is best suited.

2. Fit Your Height and Weight

Chairs and portable supports should fit your body size and weight.

3. Find Your Best Seat Height

If you sit too low, your back will tend to flatten or round into kyphosis, making even a good backrest ineffective. In addition, you may feel pressure over your buttocks and tailbone. Taller people often find seats too low for comfort. If you are tall and don't have a tall enough chair available, raise your seat with folded towels or pillows. Don't forget to raise your work surface, too, in order to attain good seated posture.

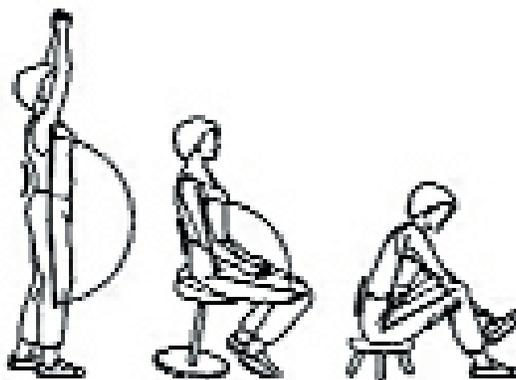
If you sit too high, you will feel pressure behind your knees and you may experience numbness or swelling in your feet. Shorter people often find seats too high for comfort. Shorter individuals need to lower their chairs and work surfaces or use a footstool at higher desks.

Remember, if you change the tilt of your seat, you may need to readjust the height of your chair.



4. Find Your Neutral Postures

The angle of your torso and thighs can help you maintain a neutral spinal posture that will keep your back comfortable. Your low-back curve deepens into an arch as your thigh-torso angle opens (for example, when you reach high overhead). Your low-back curve deepens into an arch as your thigh-torso angle opens (for example, when you reach high overhead). Your low-back curve flattens into a forward bend as your thigh-torso angle closes (for example, when you sit on a low stool).



STEP-BY-STEP CHAIR ADJUSTMENT GUIDE

First:

Observe person performing work tasks. Notice sitting habits. Ask questions such as: Are you comfortable in your chair? Do you know how to adjust your chair? Does your chair move easily from one workstation to another?

Then:

Determine whether the work surface height is appropriate for the person. If not, a keyboard tray, change to the work surface height or an adjustable height work surface should be considered. In the meantime, it may be necessary to use a footrest or other

accessories to adjust the person to the work surface. The following steps assume the work surface is at an appropriate height.

Step 1

Start by setting the seat pan height so that feet are flat on the floor (or footrest if needed).

Step 2

Check to determine that there is no pressure on the back of the knees. To make sure of this you should have 3-4 fingers' space between back of knees and edge of chair.

Step 3

If the seat has a seat-tilt adjustment, adjust the seat tilt to a position that is comfortable for the task, such as slightly downward for keyboarding.

Step 4

Then, adjust the backrest tilt, if you can, to an angle that supports the back while sitting upright between 90 and 120 degrees.

Step 5

If the backrest can be adjusted for height, move it through its lowest to highest range to find a position that puts firm pressure on the low back and supports the natural "S" curvature.

Step 6

Adjust the armrests to fully support the arms and relieve pressure from the neck-shoulder area without elevating the shoulders. Some armrests can be positioned closer and farther from the body. If so, find the appropriate position to fit the body type of the person using the chair and the work being performed. The armrests should not interfere with arm movements during tasks.

Step 7

After the chair adjustments have been made, observe the person's position while performing job tasks. It may be necessary to make adjustments to workstation and/or further adjustments to the chair.

Section 2. Laptops, Hand Tools, and Back Care

LAPTOP COMPUTER USE

Laptop computers are designed to be flexible and convenient to use. However, these same design features increase the likelihood that they will be used in settings not

ergonomically configured. There are specific guidelines and recommendations for proper use of laptops, just as there are for desktop computers. You need to be aware

of screen position, upper limb and neck postures, and wrist position. Other points to consider are described in the following recommendations.

- Equip your laptop with a full-size keyboard, a monitor, and mouse when you use it as your primary computer.
- Use a chair that provides good support for your lower back. If an ergonomic chair is not available, try using a pillow or rolled-up towel for lower-back support.
- Adjust your chair or work surface height to keep your arms in a neutral position.
- Place your wrist and hands in a neutral position. Avoid resting on the wrist while typing. Try using whole hand and arm movements to navigate around the keys.
- Keep elbows level with or slightly higher than the keyboard at approximately 90-110 degrees.
- Make sure there is no glare on the screen. Rest your eyes frequently. Laptop visual needs may be different than for a standard desktop computer. Contact your eye doctor if you experience discomfort.
- Adjust the angle of the monitor so that your head is slightly downward in a comfortable position.
- Try to type as lightly as possible.
- If your laptop has a glide point that is difficult to move, plug in an external mouse and/or use key commands.
- Select a lightweight laptop for easier carrying.
- Use friction pads or a pillow on your lap to prevent the computer from sliding.

- Take frequent, short rest breaks.

Guidelines for using laptops while traveling away from home

When using a laptop away from home, practice good ergonomic measures whenever possible. If you are in a hotel, conference room, or any other facility, don't put your laptop on a desk, table, counter or surface that is too high or that requires you to reach.

Options

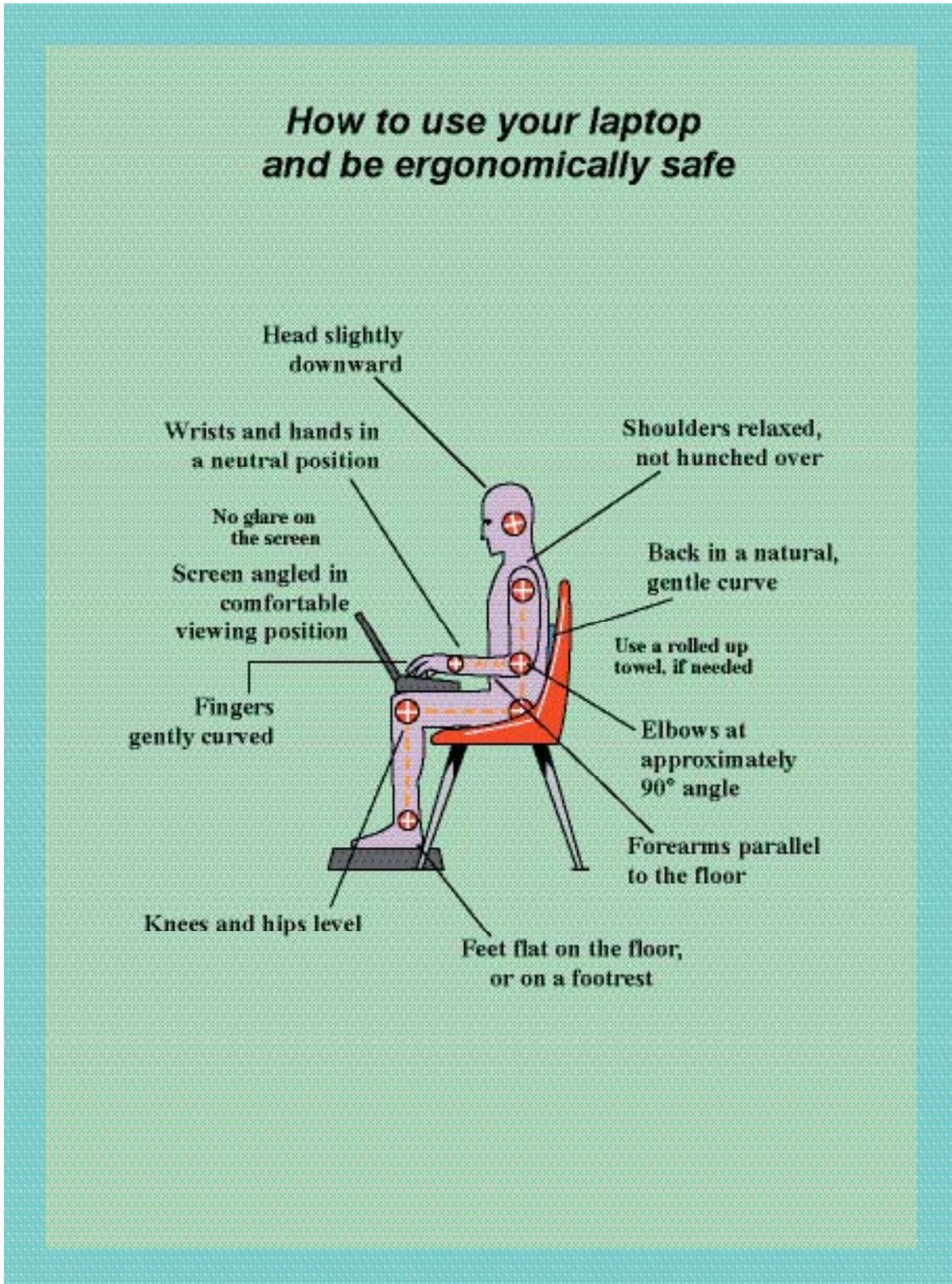
- Ask if the hotel has a docking station for laptops. If not, ask if desktop computer workstations are available so that you can plug into their keyboard and monitor.
- Use a pillow, pad, or even folded towels to raise your chair high enough so that your elbows are level or slightly higher than the keyboard (elbows at approximately 90-110 degrees).
- Sit so that your knees and hips are level, with feet on the floor or on a footrest. This will allow the laptop to rest comfortably on your lap.
- Again, adjust the angle of the monitor so that your head is slightly downward in a comfortable position.
- Choose a chair without armrests so that your elbows are free to move.
- If you elect to place your computer on a airline tray and it is too high to achieve comfort, try raising your seat height by folding one or two blankets under you. If that does work, it may be best to place the computer on your lap.

Transportation

Laptops are often heavy, which means you should avoid carrying them with a handle. Try a rolling bag designed for laptops or carrying them on your shoulder in a bag with a padded shoulder strap.

Pace Yourself

Take frequent breaks. Stand up and stretch. If you feel any strains or pains, stop what you are doing and experiment with different positions. Apply the same rules of healthy desktop computer use to laptops.



TIPS FOR SELECTING AND USING HAND TOOLS

Many household projects, such as gardening and maintenance work involve the use of hand tools. Here is a brief excerpt from the LLNL

ES&H Manual Document 19.01, LLNL Ergonomics Program. For more detailed information, go to the Web-based ES&H Manual.

Below are some key points to remember when selecting or purchasing hand tools. Following such points can help prevent MSDs (Musculoskeletal Disorders).

-
- Avoid tools that produce a bent wrist position. The ideal wrist position is neutral (i.e., straight). This position should be maintained while performing work.
 - Select hand tools that fit your hands. A tool with a handle that is too large or too small produces stresses in the hand and wrist. As a general rule, the ideal handle diameter is 1.5 inches for a man and 1.3 inches for a woman.
 - Use a soft covering on a tool handle to protect the hands from heat and cold and to help reduce pressure points, vibration, and slipperiness of the grip. Such covering encourages a more relaxed hold on the tool.
 - Respect pain. If an activity causes pain or discomfort, stop and evaluate the activity to look for alternative approaches. Change positions if the activity is causing pain or discomfort.
 - Alternate tasks during the workday to interrupt repetitive activities.
 - Use two hands whenever possible, even when handling light objects or doing small tasks.
 - To avoid the use of a sustained, forceful grip, use a vice, clamp, or jig to stabilize objects.

LIFTING AND BACK SAFETY AWARENESS

Ergonomics is not just for computer operators or hand tool users. It also applies to those who lift objects,

whether at work or at home. Injuries can happen when you lift a bulky or heavy object without assistance

or without following proper form. Injuries can even occur while lifting light objects repetitively.

Why protect your back?

Back injuries are the most common health problem in America and cause more pain and suffering than any other injury or illness. Ergonomists estimate that 90% of these injuries are preventable and twice as many back injuries occur at home as in the workplace. Protecting your back is a 24-hour job.

Types of injuries

Every time you bend over, lift a heavy object, or sit, you put stress on your lower back and spine. Over time, your back can wear out and sustain permanent damage if proper lifting techniques are not used.

Risk factors associated with back injuries

- Incorrect/improper body mechanics
- Faulty posture
- Overuse of certain muscles and joints
- Poor general health
- Trauma

- Improper lifting
- Improper diet
- Overdoing it—don't be afraid to say, "This is too heavy for me to lift alone." It's important to recognize your own physical limitations, which change with age.

Basic Principles of Lifting

- Analyze the work to be done—pre-task planning.
- Ask for help when lifting heavy object.
- Distribute the weight to be carried as evenly as possible.
- Push heavy objects rather than pull them.
- Keep objects to be carried as close to the body as possible.
- Maintain a broad base of support and a secure grip.
- Tighten the abdominal muscles and coordinate lift.
- Pivot with feet when turning and avoid turning the torso.

How to lift properly



- 1. Stand with your feet shoulder-width apart, toes pointing out.**



- 2. Bend your knee, as you lower your body, keeping the natural curves of your back. Don't bend at the waist.**



- 3. Keep shoulders back. Tighten your abdominal muscles.**



- 4. Tuck your buttocks under as you come back up. Lift with your legs.**



- 5. Keep the load close to your body.**

Section 3. Ergonomics for Children

GUIDELINES FOR COMPUTER WORK

Currently, children under the age of 18 do not often complain of many repetitive motion disorders, such as carpal tunnel syndrome and tendonitis that have plagued adults. A growing but unknown percentage of college graduates are entering the workforce with repetitive motion disorders.

When researchers around the world have questioned children and teenagers, approximately 60% report discomfort. This usually includes discomfort in the neck area, hands/wrists, back, or manifests as tired eyes, or headaches. Some research-

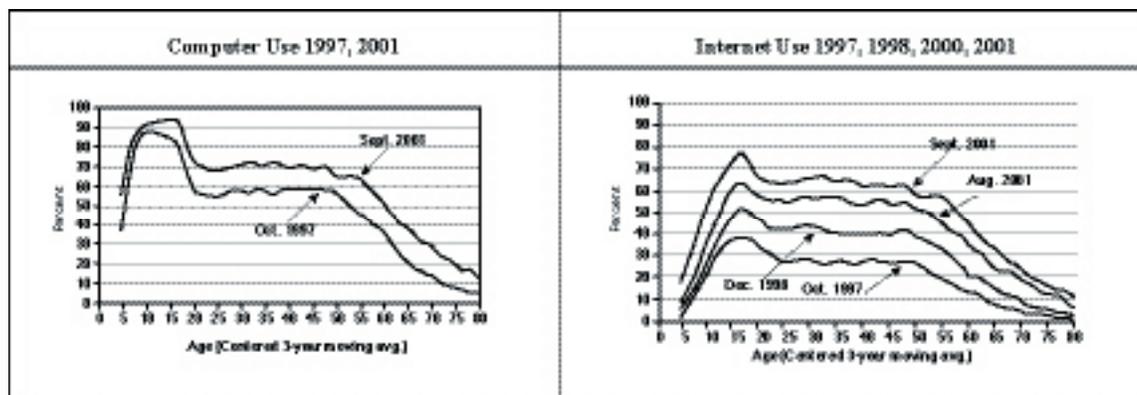
ers have found that although children and teenagers experience discomfort, they do not mention it to parents or teachers. Children may not recognize the discomfort themselves while they are engrossed in a video game. Reporting pain or discomfort experienced during computer use should be as acceptable to report as sports injuries.

What can you do? One of the most important habits to teach your child is taking breaks. Breaks ideally should be taken before the onset of discomfort. Let your child know it

is important to pay attention to the signals of discomfort and to change the activity, posture or the computer set-up. Encourage children to report discomfort of any kind.

It is not widely recognized that more 10- to 18-year-olds use computers and the Internet than any other age group.

With so many children using computers, we like to think they are comfortable. But are they? Would you know if they were not? The following pages give some guidelines for children.



Percentage of Computer and Internet Use By Age, Persons 3 to 80 Years Old

Source: NITA and EXA, U.S. Department of Commerce, using U.S. Census Bureau Current Population Survey Supplements

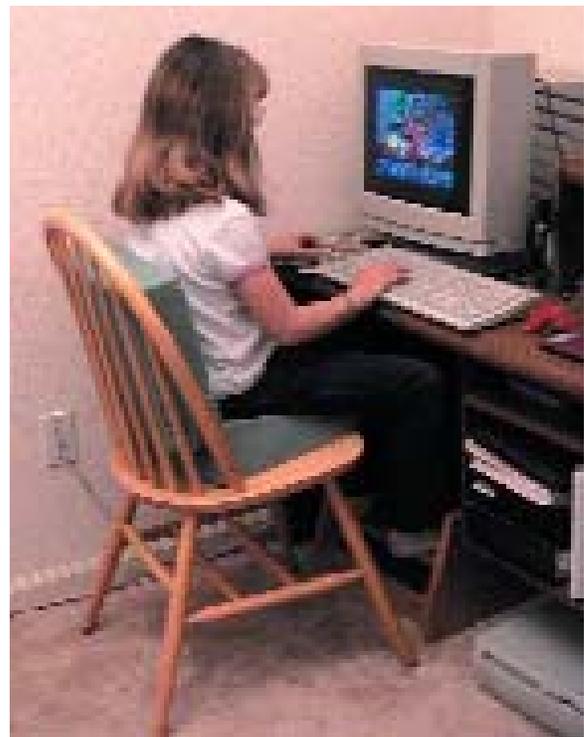
GUIDELINES FOR YOUTH

Computers

1. TAKE BREAKS! Set a timer and be sure to get up every 20 or 30 minutes. Shake out your hands, stretch, and move around.
2. Sit comfortably. There's more than one-way to sit right. As long as your back and feet are supported and head and neck are in line with the spine (not flexed forward or extended back), many postures can be okay.
3. If your feet don't reach the floor, make sure you have a footrest or something to support your feet.
4. If your family has an adjustable chair test out the possible adjustments. Find the settings that make you comfortable. Everyone in the family should be encouraged to make adjustments upon sitting in the chair.
5. Change positions frequently.
6. Try to have the top of the monitor close to eye level. If you need to, raise the chair or put cushions on the chair to raise your sitting level. Make sure your head doesn't have to tilt backwards to see the screen.
7. Sit so the keyboard is at or slightly below elbow level. You may need to raise your seating height or lower the keyboard but this can help you from getting tired hands, arms, shoulder or neck.
8. Make sure there is a straight line from your elbows through your fingertips. The wrist should not be bent up, down or to the side for long periods of time.
9. Don't squeeze the mouse or clutch the trackball. Doing this means unnecessary tension in your hands and can become a habit that makes you very uncomfortable even after you stop using the computer.
10. Eyes need a rest break too. Blink frequently and focus on something beyond your computer (like the other side of the room or out the window) every 20 minutes.



Computer workstation not adjusted for youth.



Computer workstation adjusted for youth.

Electronic Games

1. Keep wrists straight and hands loose, not tense. A straight line from elbow through wrists without sideways bending toward your little finger or thumb is best.

2. Keep your chin up with hand-held games like Gameboy. Sitting with your head hanging from your neck can give you a pain in the neck!

3. Support your arms. Use a pillow or two under your arms to hold them up if you want the controls higher than your lap. This will help keep you from bending your head down too.

4. When playing games that use the television monitor, sit back so that you can see the television screen without tilting your head back.

5. A neutral head and neck posture is best.

6. TAKE BREAKS! Set a timer and be sure to get up every 20 or 30 minutes. Shake out your feet too as they can go to sleep from sitting on them. Some kids have broken or sprained their ankles from trying to walk on them when they were “asleep.”



Bad, but typical posture while playing electronic games.



Options for improving posture while playing electronic games.



BACKPACK SAFETY

If backpacks are too heavy (more than 10% of body weight) they can:

- Affect your posture
- Affect how your spine develops
- Affect your breathing
- Give you a pain in the back—or neck!

To keep your backpack from being a pain:

- Put heavy items where they will be close to your back and/or in the bottom of the backpack.
- Empty your backpack every weekend. (There might be things you don't need to keep carrying around.)
- Wear your backpack with both straps snug over your shoulders.

Consider taking the weight off. Use a wheeled backpack.



Bad example of carrying backpack



Good options for carrying backpack.



USEFUL WEB SITES FOR ERGONOMICS INFORMATION

Ergonomics information for LLNL employees:

<http://www.llnl.gov/ergo/>

Ergonomics information for computer workstations:

<http://www.backdesigns.com>

Free software to remind you to take rest breaks:

<http://www.tifaq.com/software/shareware.html>

Ergonomic Tools for the Garden:

<http://www.lifewithease.com/garden.html>

<http://gardening.fiskars.com/tips.html?cat=ergonomics>

Tool Box Safety Tips:

<http://www.nsc.org/issues/firstaid/toolbox.htm>

Youth Ergonomics:

Mavis Beacon Teaches Typing for Kids:

<http://www.dirtcheapsoftware.com/mavbeactact1.html>

Section 4. Ergonomic Resources and Web Site

RESOURCES FOR ERGONOMICS EQUIPMENT

OFFICE MAX

www.officemax.com

1-800-788-8080

City: Livermore

Phone: (925) 294-5609

OFFICE DEPOT

www.officedepot.com

1-888-GODEPOT

City: Dublin

Phone: (925) 803-1860

STAPLES

www.staples.com

1-800-3STAPLE

City: San Ramon

Phone: (925) 552-1960

IKEA

www.ikea.com

1-800-434-4532

City: Emeryville

Phone: (510) 420-4532

FRY'S ELECTRONICS

www.frys.com

City: Fremont

Phone: (510) 252-5300

These resources may be able to provide additional information on retailers in your geographic area. Your local phone directory may also list resources for ergonomic equipment.

Disclaimer:

This list is not intended to endorse any specific store. It to be used only as a guide to help individuals find needed equipment. Many other stores may carry similar equipment.

Be aware that not all equipment sold as "ergonomic" is truly well designed. Who is using equipment and how it is being used makes it ergonomic or not.

University of California
Lawrence Livermore National Laboratory
P.O. Box 808
Livermore, California 94551



DISCLAIMER

This document was prepared as an account of work sponsored by an agency of the United States Government. Neither the United States Government nor the University of California nor any of their employees, makes any warranty, express or implied, or assumes any legal liability or responsibility for the accuracy, completeness, or usefulness of any information, apparatus, product, or process disclosed, or represents that its use would not infringe privately owned rights. Reference herein to any specific commercial product, process, or service by trade name, trademark, manufacturer, or otherwise, does not necessarily constitute or imply its endorsement, recommendation, or favoring by the United States Government or the University of California. The views and opinions of authors expressed herein do not necessarily state or reflect those of the United States Government or the University of California, and shall not be used for advertising or product endorsement purposes.

This work was performed under the auspices of the U. S. Department of Energy by the University of California, Lawrence Livermore National Laboratory under Contract No. W-7405-Eng-48.



Printed on recycled paper.